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ABSTRACT

Children in sensorimotor and preoperational stages, as well as at the preschool level, learn fundamental mathematics concepts daily through experiences in the environment. When children enter formal learning environments, they are active, curious, egocentric, and verbal. It is hoped that they will encounter capable teachers who can choose appropriate learning activities and implement them skillfully. Of course, the child's interaction with the teacher will be mediated by the curriculum. In the area of mathematics, readiness skills for formal early education include classifying, comparing, ordering, patterning, one-to-one correspondence, conservation of number, rational counting, recognizing cardinal and ordinal numbers, number recognition, and writing numerals. For optimal learning, pre-number skills should be taught with real objects. Such "manipulatives" should be carefully selected according to several criteria, including, among others, attractiveness, simplicity, versatility, safety, and economy. In conclusion, examples of sequenced learning activities involving manipulatives are offered. Activities at concrete, semi-concrete, and abstract learning levels are provided for the pre-number skills of ordering and number recognition. Each learning activity specifies learning level, skill, materials, and procedure. (RH)

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M & M's - Mathematics and Manipulatives, m-m-m good!

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M & M's - Mathematics and Manipulatives, m-m-m good!

Bitsy Browne Miller and Ann Harsh

This presentation focuses on the importance of teaching mathematics through the use of manipulatives. It is hoped that you will find that just as M & M's are enticing to young children so is learning mathematics through manipulatives.

The following Chinese proverb expresses the writers' philosophy about teaching young children in all subject areas, especially in mathematics:

I hear, and I forget
I see, and I remember
I do, and I understand.

Mathematics surrounds all of us in our daily lives and to function successfully we must learn to understand and utilize mathematical concepts to address our needs. The basic understanding of these mathematical concepts begins, believe it or not, in infancy. For example, the infant, in what Piaget has called the sensorimotor stage, explores the world with his senses; he:

(1) looks about and sees his relative smallness - many objects and people in his world are bigger than he is;

(2) is constantly grasping objects, and as he wraps his tiny fingers around a toy or whatever, he finds that some objects fit his hand and some do not;

(3) learns about the concept of weight when he experiences the fact that items of the same size cannot always be lifted with equal ease;

(4) learns about shape when some things such as cubes stay put, while other things roll away;

(5) develops a fundamental understanding of sequence when he wakes up, feels wet and hungry, then cries; mom comes to the rescue, changes and feeds him, then plays with him; and soon the same events are repeated;

(6) develops an idea of space as he begins to move, at first within the confines of his crib, then on the floor. As the child becomes more mobile his concept of space expands.

The Toddler, in what Piaget has called the preoperational stage, continues his learning of mathematical concepts as he:

(1) engages in sorting objects into piles of the same color, size, or shape;

(2) pours water into containers of different sizes and realizes that not all the water from the bucket will fit into the cup;

(3) mimics what he sees at home. For example, as the child cooks imaginary foods he remembers that mom measured cups of some things and teaspoons of others. The child also mimics routine home activities as he sets the table with one plate, one fork, one knife, and one spoon, thereby developing a beginning understanding of one-to-one correspondence.

As the preschool child continues to progress in his basic understanding of fundamental mathematical concepts, he experiences:

(1) making judgements (the beginning of the reasoning process) as he gauges the space he needs to get his tricycle through the door, estimates how high to raise his foot to climb upon the jungle gym, estimates the size block he needs to fill a particular space, and decides exactly where to position an object to make it balance;

(2) understanding "number" as he realizes that someone else got more cookies than he did, thereby exhibiting a basic understanding of one-to-many correspondence;

(3) concepts of money and its value as he inserts a coin into a machine to purchase a toy or a treat of some kind, selects a coin to give as an offering in sunday school, and observes his parents making daily purchases.

All of these experiences and many more constitute the young child's natural and daily mathematical environment. These

experiences take on new and/or additional meaning as the child matures and moves into more formal learning situations. This early learning of simple mathematical concepts helps bridge the gap between home and preschool and preschool and the primary grades.

In focusing on formal early education several elements should be considered. The child, the teacher, and the curriculum are essential components of any educational program.

CHILD

Since the child is the central focus of early childhood education, an examination of some major characteristics of the young child is appropriate. After all, we must know the child and understand his capabilities before we can teach him.

The young child is:

ACTIVE, so we must capitalize on this energy (his needs, his interests, his experiences) and put it to good use through the proper materials. It is because of the child's need for activity that the use of manipulatives is emphasized.

CURIOUS about his environment, so we must make it stimulating and attractive in order to motivate him.

EGOCENTRIC - he can see situations only from his perspective so we must provide experiences which "fit" his world.

VERBAL - his language is a significant learning tool. This is why oral communication is important between teacher and child, and among the children themselves.

Only a few characteristics of the young child have been mentioned. If more information is needed, there are many excellent child development books such as those included in the bibliography.

TEACHER

Another essential element of formal early education is the teacher. In addition to the child's primary caregivers, a good teacher is probably the most valuable person in the young child's life. In fact, research supports what we already know about the importance of teachers. Several recent studies concerning mathematics in the early childhood curriculum indicate interest and enthusiasm of the teacher is what actually affects achievement the most, not the materials (Reys, 1972). In other words learning mathematics depends more on the teacher than on the materials used.

Who then is the good and caring teacher of young children? What are his/her characteristics? A good (mathematics) teacher is that person who:

1. has knowledge of subject matter and methods through which concepts can best be understood by students;

2. can facilitate the development of mathematical competencies as well as foster a positive atmosphere by showing respect for each student;

3. is sensitive to individual students - one who listens and answers obvious questions as well as those which appear only on the faces of the children;

4. chooses learning activities and experiences with care according to the needs of a group and the individuals within that group. This is accomplished by using a wide variety of reinforcement and enrichment materials.

5. is accepting of errors that will occur - one who encourages students to take risks in asking and responding to questions. This type of teaching stimulates children to realize that there is not just one correct answer or one way to solve a problem;

6. is adept at teaching through the use of questioning. Great teachers of the past, from Socrates to Piaget, have guided

students into learning by probing their responses in order to explore and/or clarify concepts. An example of teaching through questioning can be found in the following Piagetian type of "interview" based on the Socratic method of teaching (Maffei & Buckley, 1980).

Teacher: How many apples do you see?
Child: 8.
Teacher: How did you get 8 apples?
Child: I counted by groups.
Teacher: Show me how you counted by groups.
Child: 2, 4, 6, 8.
Teacher: Why did you count that way?
Child: It's easy to see groups of two.
Teacher: Is there any other way you could count the apples?
Child: Sure!
Teacher: How?

Not only does this teaching method enable the teacher to "test" the depth of the child's learning, but it also encourages divergent thinking.

CURRICULUM

The third element that needs to be considered when describing formal early education is the curriculum. It consists of concepts and skills that are considered prerequisites for the young child's work with number. Some educators call these readiness skills or pre-number skills. Eleven of these skills and their importance to later success in mathematics will be discussed.

1. Classifying is the process of sorting objects according to an attribute or characteristic such as size, shape or color. Classification skill helps the child think analytically and express thoughts clearly, both of which are important to good mathematical reasoning. Classification skill is necessary when the child attempts to add apples and oranges and realizes he must reclassify them as fruit to complete the operation.

2. Comparing is the process by which the child establishes a relationship between two objects or sets on the basis of some specific characteristic or attribute like height, weight or length. The ability to compare contributes to mathematical understanding which prepares the child for the comparison of

numbers using such terms as "more than", "less than", and "equal to".

3. Ordering builds on comparing. It involves comparing more than two things or two sets and placing them in a sequence according to some rule such as arranging them shortest to tallest or smallest to largest. The ability to arrange things in a particular way is a prerequisite for counting.

4. Patterning is a process of recognizing a pattern visually, aurally, or physically; analyzing that pattern; and then duplicating or continuing it. This skill has been called the underlying theme of mathematics. Patterning skill aids in development of the meaning of numerical symbols. As children learn to recognize dot patterns for numerals, they can look at the patterns and know without counting what each represents.

5. One-to-one correspondence is the process of matching one object to another such as one cookie to one child or one sock to one shoe. It has been called the most basic component of number. One-to-one correspondence is essential to rational counting by which the child matches objects in a set with the set of counting numbers.

6. Conservation of number is the process of holding in memory a set of objects that do not change in value but do change in position. It is believed that conservation of number is a necessary prerequisite skill to success with mathematical operations such as addition and subtraction (Charlesworth & Radeloff, 1978).

7. Rational counting (meaningful counting) involves attaching a numeral name in order to a series of objects in a group. It is simply a higher level of matching or one-to-one correspondence. This skill is basic to calculating cardinality and ordinality of sets.

8. Recognizing cardinal numbers involves rational counting to determine how many objects are in a set. This recognition is important in performing addition and subtraction operations on the concrete and semi-concrete level.

9. Recognizing ordinal numbers is an extension of rational counting. It refers to the order of an object in a set using terms such as "first", "second", "third." It answers the question "which one?" Ordinal number is a useful skill in problem solving.

10. Number recognition is the process of recognizing the symbol as well as understanding the meaning (value) of it. This skill is a prerequisite to all mathematical operations. A child needs to recognize numbers in a meaningful way so that mathematics will not be a rote, inefficient process.

11. Writing numerals is the process of recognizing numerical symbols and then being able to trace, copy, and finally independently produce them from memory. Writing numerals is a necessary skill for mathematical paper and pencil activities.

These eleven skills are considered the stepping stones to success with number in a sequential mathematics curriculum where the first skills lay the foundations for subsequent ones. Research indicates these skills should be taught following the Teaching Learning Sequence through which children first work with real objects, then move to pictorial representations, and finally to abstract symbols (Kennedy, 1980).

MANIPULATIVES

Teaching pre-number skills with real objects (manipulatives) is not new. Many years ago Pestalozzi, Froebel, and Montesorri developed materials for children that emphasized experiences with real objects. However, it was not until the 1930's that people in the United States began to realize the importance of manipulatives. With their studies on learning, Piaget, Bruner, Gagné, and Skemp have strengthened this point of view (Kennedy, 1980). Now, many child development specialists, educators, and psychologists believe the curriculum for the preschool child should be based on learning with manipulatives.

The findings of the Suydam and Higgins (1977) research survey support these claims. These researchers found:

1. Lessons using manipulative materials have a higher probability of producing greater mathematical achievement than do non-manipulative lessons.

2. Symbolic treatments are not as effective as those in which

manipulative materials are used.

3. The use of manipulatives appears to be effective with children at all achievement levels, ability levels, and socioeconomic levels.

Paper and pencil learning as well as workbook pages in beginning mathematics are considered the least effective methods of learning because the child can't act upon them. Also, research indicated that young children have difficulty interpreting pictures on workbook pages (Campbell, 1981). The use of workbooks or worksheets should never be the child's first exposure to learning mathematics. Only after the child has had opportunities to actually classify, compare, and order objects should the semi-concrete workbook pages be used and even then with caution.

Since manipulatives are important, there are several criteria which must be considered in their selection. Manipulatives should be:

1. colorful, interesting, and attractive;
2. simple to use;
3. action oriented - the child actually does something with them;
4. versatile;
5. carefully chosen based on the child's needs;
6. self-correcting if possible;
7. appropriate in size, weight, and difficulty;
8. durable;
9. safe with smooth edges and non-toxic paint;
10. easily supervised;
11. economical.

Manipulatives can be beneficial because they provide hands-on activities that enable children to experience learning. Manipulatives motivate and serve the child-centered curriculum well allowing for reinforcement and enrichment. They can also reduce the fear of mathematics thus creating

positive attitudes. Working with manipulatives and conversing about specific activities can give the teacher insight into the child's strengths and weaknesses. Furthermore, manipulatives can promote successful learning as well as lend variety to the teaching methods.

SPECIFIC EXAMPLES OF ACTIVITIES

The Teaching Learning Sequence mentioned earlier emphasizes the utilization of concrete, semi-concrete, and abstract materials. This sequence should be used with young children so the following pre-number activities will be included in this publication:

ORDERING

Tall, Taller, Tallest

Learning Level:	Concrete
Skill:	Ordering a set of three or more objects according to height by using a direct comparison technique.
Materials:	A set of cardboard or plastic animals of varying heights or a variety of other objects (straws, sticks, socks, paper dolls, geometric shapes, buttons, etc.).
Procedure:	The teacher removes an animal from the set before allowing the child to observe the set. The child is asked to arrange the animals from shortest to tallest. When the task is completed the child is given the animal that the teacher removed to see if it can be correctly placed in the arrangement. (Sohns & Buffington, 1977, pp. 18, 19)

Plant Sequence Cards

Learning Level: Semi-concrete

Skill: Ordering events in a logical sequence.

Materials: 5 tagboard cards, 3" X 5"; colored felt-tip pens; and clear contact paper.

Procedure:

1. The teacher draws one sequence stage on each card as follows:
   a. Dig hole.
   b. Drop in seed.
   c. Cover seed with soil.
   d. Water seed.
   e. Seed grows into plant.
2. For self correcting purposes, the text can be written on the back of each card. The cards can be numbered or symbols may be used in a certain order to indicate correct sequence.
3. The teacher covers all cards with clear contact paper.
4. The teacher discusses the sequence of events with the children and lets them verbalize why this order must be followed.
   (Debelak, Herr, & Jacobson, 1981, pp. 280, 281)

The Nurse Game

Learning Level: Abstract

Skill: Ordering numerals from smallest to largest; numeral recognition.

Materials: Poster paper, scissors, magic markers, rubber cement, xeroxed nurse pictures, and clear contact paper.

Procedure: The teacher writes a numeral on each picture of the nurses and laminates them. The child identifies the numerals on the nurses and places them in order (smallest to largest).
(Dellosa & Carson, 1977, p. 97)

NUMBER RECOGNITION

Eggs, Eggs, Eggs

Learning Level: Concrete

Skill: Number recognition.

Materials: Styrofoam egg carton, plastic eggs, small adhesive dots, adhesive numerals, and small objects that fit inside the eggs (jacks, paper clips, small balls, buttons, etc.).

Procedure: The teacher places the numerals and the corresponding dots on each egg. The child fills each egg with as many objects as indicated by the numeral on the egg.
(Jensen & O'Neil, 1982, pp. 7-13).

Let's Take A Dip

Learning Level: Semi-concrete

Skill: Number recognition.

Materials: Poster paper, magic markers, and clear contact paper.

Procedure: The teacher traces ten sets of ponds, mother ducks, and baby ducks; colors and covers them with contact paper. Ponds are labeled with number words, mother ducks with numerals (1 - 10), and baby ducks with appropriate dot patterns. The child reads the number word on each pond and places the correct mother and baby duck pair in the pond.
(Dellosa & Carson, 1977, p. 9)

Musical Math

Learning Level: Abstract

Skill: Number recognition.

Materials: Songs from Math Magic ("Where Oh Where Are All the Numerals?", "The Numeral One", and large numerals (1-10).

Procedure: The teacher and children sing the songs and hunt numerals around the room. (Kahn, 1976, pp. 26, 27; 36, 37)

CONCLUSION

In closing, just as M & M's are a treat so is learning mathematics with manipulatives. Manipulatives are an enjoyable way to gain meaning in mathematics. Kids will love them! They are colorful and they will flavor their attitudes in a positive way toward mathematics.

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